



VERIFICATION OF TRANSLATION

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Signed this 11th day of May, 2007

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[Claim 1] An alkaline storage battery incorporating an electrode group comprising cathode, that the cathodes each include a cathode active material composed mainly of nickel hydroxide, and anodes, disposed in such a way as to oppose each other with a separator interposed therebetween,

wherein the cathodes having cathode active material composed mainly of the nickel hydroxide, having a layer of coating of cobalt compound, and to which at least one species of a compound selected from the group consisting of a niobium compound, titanium compound, tungsten compound and molybdenum compound is added,

while the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound and molybdenum compound for each of the nickel cathodes disposed in inner parts of the electrode group is greater than that for each of the nickel cathodes disposed on the outer sides of the electrode group.

[Claim 2] An alkaline storage battery according to claim 1, wherein at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound and molybdenum compound is introduced into each of the cathodes such that the amount of at least one species of a compound for each of the nickel cathodes increases in sequence from the outer portion of the electrode group toward the inner portion thereof.

[Claim 3] An alkaline storage battery according to claim 1 or 2, wherein the cobalt compound coating the nickel hydroxide is a cobalt compound containing alkali metal ion.

[Claim 4] An alkaline storage battery according to one of any claims 1 to 3, wherein the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound and molybdenum compound, to be added to each of the nickel cathodes disposed in the inner parts of the electrode group, is not less than 0.2% by mass in relation to the mass of the cathode active material composed mainly of the nickel hydroxide, having a layer of coating of cobalt compound.

[Name of the Document] Specification

[Title of Invention] Alkaline Storage Battery

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to an alkaline storage battery such as a nickel-hydrogen battery, nickel-cadmium battery, etc., and in particular, to an alkaline storage battery comprising nickel cathodes (positive electrode) containing a cathode active material composed mainly of nickel hydroxide and an alkaline electrolytic solution.

[0002]

[Relevant Art]

The range of uses of secondary batteries (storage batteries) has lately become broader, and storage batteries have come to be used in a wide variety of equipment including personal computers, mobile phones, electric cars, hybrid cars, motor-operated bicycles, electric tools, etc., have been put to use as the power source of equipment requiring high output, such as electric cars, hybrid cars, motor-operated bicycles, electric tools, etc. In addition, the alkaline storage battery has become more significant because it can be used even in a high-temperature atmosphere.

[0003]

Accordingly, in Patent Document of JP, H 8-222213, A, an alkaline storage battery has been proposed wherein a layer of an electrically conductive agent composed of a cobalt metal or cobalt compound is made to form on the surface of cathode active material particles composed mainly of nickel hydroxide while one species of compound selected from the group consisting of a zirconium compound, niobium compound, molybdenum compound, and tungsten compound is introduced into cathodes comprising the cathode active material particles.

[0004]

If one species of compound selected from the group consisting of the zirconium compound, niobium compound, molybdenum compound, and tungsten compound is introduced into the cathodes as described above, the rate at which the cobalt compound coating the surface of the cathode active material composed mainly of nickel hydroxide is dissolved and precipitated in an alkaline electrolytic solution can decrease and the layer of the cobalt compound can become denser in structure, thereby enabling an excellent electrically conductive network to be maintained in the nickel cathode. Accordingly, the oxygen generating overvoltage becomes higher, so that the oxygen generation reaction can be

inhibited, thereby enhancing recharging efficiency.

[0005]

[Problems to Be Resolved by the Invention]

However, at the time of recharge/discharge operations, the temperature in the inner portion of the electrode group increases, so that there occurs a difference in temperature between the inner portion and the outer portion of the electrode group, and in the case of the alkaline storage battery to be used in a high-temperature atmosphere, the temperature in the inner parts of the battery rises to a considerably high level. Consequently, degradation rates of the cathodes disposed in the inner portion of the electrode group differ from those of the cathodes disposed on the outer portion of the electrode group due to a rise in the temperature of the cathodes disposed in the inner portion of the electrode group. The same problem occurs in the above-described alkaline storage battery where one species of a compound selected from the group consisting of zirconium compound, niobium compound, molybdenum compound, and tungsten compound is introduced into the cathodes comprising the cathode active material provided with a layer of an electrically conductive agent composed of cobalt metal and a cobalt compound.

[0006]

Thus, if the degradation rate of the cathode disposed in the respective inner portion of the electrode group increases during high temperature, the cycle life of the battery as a whole is shortened due to a higher degradation rate of the cathode. Therefore, the invention is intended to provide an alkaline storage battery with an excellent cycle life at high temperature, capable of inhibiting degradation of cathodes disposed in the inner portion of the electrode group so as to maintain a balance between the degradation rate of the cathodes disposed in the inner portion of the electrode group and the degradation rate of cathodes disposed on the outer portion of the electrode group even if there occurs a difference in temperature between the inner part and the outer side of the electrode group.

[0007]

[Means of Solving the Problems]

To that end, cathodes of the alkaline storage battery, includes a cathode active material composed mainly of nickel hydroxide, having a coating layer of a cobalt compound, and is added with at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound and molybdenum compound while the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium

compound, tungsten compound and molybdenum compound to be added to each of the nickel cathodes disposed in the inner portion of the electrode group is greater than that for each of the nickel cathodes disposed on the outer portion of the electrode group.

[0008]

If at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound is introduced into the nickel cathodes as described above, the rate at which the cobalt compound coating the surface of an active material layer and composed mainly of nickel hydroxide is dissolved and precipitated in the alkaline electrolytic solution can be reduced and therefore maintenance of an excellent electrically conductive network in the nickel cathodes would be possible. In this case, the nickel cathodes must reside in the respective inner parts of the electrode group for greater effectivity. Thus, it becomes possible to maintain a balance between the degradation rate of the cathodes disposed in the inner portion of the electrode group and the degradation rate of the cathodes disposed on the outer portion of the electrode group even if there occurs a difference in temperature between the inner portion and the outer portion of the electrode group, thereby providing an alkaline storage battery with an excellent cycle life at high temperature.

[0009]

Further, it has been found that increasing the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound, added to the cathode disposed on the respective outer portion of the electrode group has an adverse effect on the cycle life of the alkaline storage battery at high temperature and therefore needs to be controlled.

[0010]

On the one hand, if the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound, added to the cathode disposed in the respective inner parts of the electrode group is insufficient, there is no advantageous effect by way of improving the cycle life of the battery at high temperature. Accordingly, the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound, to be added to the cathode disposed in the respective inner portion of the electrode group should preferably be not less than 0.2% by mass.

[0011]

On the other hand, if the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound, to be added to the cathode disposed in the respective inner portions of the electrode group is excessively increased, the high rate discharge characteristic of the battery at room temperature deteriorates. Accordingly, the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound, to be added to the cathode disposed in the respective inner portions of the electrode group, should preferably correspond to the minimum required amount for maintaining a satisfactory life cycle.

[0012]

In such a case, the conductivity of the layer of the cobalt compound would be further enhanced if it contains alkali metal ion.

[0013]

[Embodiment of the Invention]

Embodiments of the invention are described in detail hereinafter with reference to Fig. 1. However, it is posited that the invention is not limited thereto, and various changes and modifications as appropriate may be made without departing from the spirit and scope of the invention. Fig. 1 is a schematic section view of an alkaline storage battery according to the invention.

[0014]

1. Nickel Cathodes

(1) Fabrication of Nickel Cathode Plates

While stirring an aqueous solution composed of a mixture of nickel sulfate, zinc sulfate, and cobalt sulfate, containing 3 parts by mass of zinc and 1 part by mass of cobalt against 100 parts by mass of nickel metal, respectively, an aqueous solution of sodium hydroxide was gradually added thereto and the pH of the reaction solution was maintained within the range of 13 and 14, thereby causing nickel hydroxide in grain form to be precipitated. An aqueous solution of cobalt sulfate was further added to the solution wherein the nickel hydroxide in grain form was precipitated, and the pH of the reaction solution being maintained at a range of 9 to 10, while spherical hydroxide particles composed mainly of nickel hydroxide were used as nuclei of crystals, thereby causing cobalt hydroxide to be precipitated around the respective nuclei.

[0015]

Thus, nickel hydroxide particles with a coating layer of cobalt hydroxide

on the surface were obtained. Thereafter, alkaline heat treatment was applied to the nickel hydroxide particles, whereby an alkaline solution was sprayed thereto in a hot air flow. During the alkaline heat treatment, temperature was adjusted such that the temperature of the nickel hydroxide particles was kept at 60°C, and 35% by mass of an alkaline solution (aqueous solution of sodium hydroxide), equivalent to 5 times as much as the parts by mass of cobalt, were sprayed. Subsequently, temperature was raised until the temperature of the nickel hydroxide particles reached 90°C. Then, the nickel hydroxide particles were washed with water and dried at 60°C and thereafter turned into cathode active material. In so doing, nickel hydroxide powders (the cathode active material) with a highly conductive coating of a cobalt compound containing sodium (alkali metal ion), formed on the surface of the nickel hydroxide particles, were obtained. [0016]

Subsequently, after making the mixture by adding a niobium compound (e. g., Nb_2O_5) to the cathode active material prepared in the above described manner, 200 g of a dispersion liquid containing 0.25% by mass of HPC (hydroxylpropyl cellulose) were added to and mixed with 500 g of the mixture, thereby producing an active material slurry. A cathode active material prepared by adding Nb_2O_5 so as to percentage in relation to the mass of the cathode active material be 0.1 % was designated as cathode active material a1. Further, a cathode active material prepared by adding Nb_2O_5 so as to percentage in relation to the mass of the cathode active material be 0.2 % was designated as cathode active material b1, and a cathode active material prepared by adding Nb_2O_5 so as to percentage in relation to the mass of the cathode active material be 0.5 % was designated as cathode active material c1. Further, a cathode active material prepared without adding Nb_2O_5 (niobium compound) was designated as cathode active material d1. In case a niobium compound is used, the compound may be selected from the group consisting of Nb_2O_3 , NbO , NbO_2 , NaNbO_3 , LiNbO_3 , KNbO_3 , and $\text{Nb}_2\text{O}_5 \cdot x\text{H}_2\text{O}$, besides Nb_2O_5 . [0017]

Thereafter, the active material slurry a1 through d1 was filled in corresponding electrode base plates made of porous nickel 1.7 mm thick so as to reach a predetermined packing density. Subsequently, the respective electrode base plates were dried and rolled to a thickness of 0.95 mm, then cut to a predetermined size, thereby preparing nickel cathode plate 11 (a, b, c, d), respectively. A nickel cathode plate prepared by using the active material slurry a1 was designated as nickel cathode plate a, a nickel cathode plate prepared by using the active material slurry b1 was designated as nickel cathode plate b, a

nickel cathode plate prepared by using the active material slurry c1 was designated as nickel cathode plate c, and a nickel cathode plate prepared by using the active material slurry d1 was designated as nickel cathode plate d, respectively.

[0018]

2. Fabrication of Hydrogen Storing Alloy Anode Plate

After mixing mesh metal (Mm), nickel (Ni: purity 99.9%), cobalt (Co), Manganese (Mn), and aluminum (Al) together at a predetermined mole ratio, respectively, the mixture obtained was subjected to induction heating in an argon atmosphere inside a high frequency induction furnace to be thereby turned into molten alloy. The molten alloy was thereafter poured into a mold by the publicly known method, and after cooling, an ingot of hydrogen storage alloy expressed by a composition formula $MmNi_aCo_bMn_cAl_d$ was prepared. The ingot of the hydrogen storage alloy was pulverized through a mechanical crushing method to about 60 μm in average grain size.

[0019]

Subsequently, hydrogen storage alloy paste was prepared by mixing 20 parts by mass of an aqueous solution of 5% by mass of polyethylene oxide (PEO) as a binder with 100 parts by mass of hydrogen storage alloy powders. The hydrogen storage alloy paste was thereafter applied to both surfaces of a core body made up of punching metal, and dried at room temperature. The workpiece thus obtained was cut to a predetermined size, thereby producing a hydrogen storage alloy anode plate 12.

[0020]

3. Fabrication of Nickel-Hydrogen Batteries

Using four nickel cathode plates 11 (a, b, c, d), and five hydrogen storage alloy anode plates 12, separately prepared as previously described, with a separator 13 made of nonwoven fabric of polypropylene, interposed therebetween, respectively, the nickel cathode plates 11 were alternately laminated to the hydrogen storage alloy anode plates 12, respectively, in such a way as to oppose each other. Subsequently, cathode conductor tabs 11a disposed on the nickel cathode plates 11, respectively, were welded with each other while anode conductor tabs 12a disposed on the hydrogen storage alloy anode plates 12, respectively, were welded with each other. Subsequently, a cathode current collector 14 was welded to the welded cathode conductor tabs 11a, thereby forming an electrode group. Thereafter, the electrode group was inserted into an outer case 15 in box-like shape, and subsequently, the cathode current collector 14 was welded to the lower end of a cathode terminal member 16c of a sealing body 16.

Then, an alkaline electrolytic solution of a predetermined concentration was poured into the outer case 15, and an opening of the outer case 15 was sealed with the sealing body 16, thereby fabricating a nickel-hydrogen battery square in shape with a nominal capacity of 900 mAh.

[0021]

The sealing body 16 comprises a lid 16a made of metal, substantially rectangular in shape, having an opening in the center thereof; an insulator plate 16b made of a synthetic resin, substantially rectangular in shape, and disposed underneath the lid 16a, having an opening in the center thereof; the cathode terminal member 16c substantially in box-like shape inserted into the openings; a gasket 16d disposed between the lid 16a and the cathode terminal member 16c for insulating the cathode terminal member 16c from the lid 16a while implementing liquid-tightness therebetween; and a cathode cap 16e disposed on top of the cathode terminal member 16c, and welded to the top side thereof.

[0022]

After replacing the sealing body 16 constructed in the manner described above over an opening of the outer case 15, the periphery of the lid 16a is laser-welded with the inner peripheral face of the upper part of the outer case 15, thereby sealing the outer case 15 so as to be liquid-tight. Furthermore, a valve 16f having elasticity is made to reside inside the cathode cap 16e, so that if gas is emitted inside the battery and pressure therein rises to a level higher than a predetermined pressure, the valve 16f undergoes elastic deformation, thereby enabling the gas emitted inside the battery to be released through a gas vent 16g provided in the cathode cap 16e. Thus, since the valve 16f functions as a safety valve, pressure rise inside the battery can be prevented.

[0023]

A battery prepared by using an electrode group wherein the cathode plate d without the addition of a niobium compound is disposed as a cathode plate 11-1 on respective outer portions (on the sides adjacent to the outer case 15) of the electrode group, and the cathode plate d is disposed as a cathode plate 11-2 in respective outer inner parts of the electrode group was designated as battery A1. Similarly, a battery prepared by using an electrode group wherein the cathode plate c with the addition of 0.5% by mass of a niobium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the same cathode plate d without the addition of a niobium compound is also disposed as a cathode plate 11-2 in respective outer inner parts of the electrode group was designated as battery A2. Further, a battery prepared by using an electrode group wherein the cathode plate d without addition of a niobium compound is

disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate a with addition of 0.1% by mass of a niobium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery A3.

[0024]

And further, a battery prepared by using an electrode group wherein the cathode plate d without addition of a niobium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate b with addition of 0.2% by mass of a niobium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery A4. Further, a battery prepared by using an electrode group wherein the cathode plate d without addition of a niobium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate c with addition of 0.5% by mass of a niobium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery A5. And further, a battery by using an electrode group wherein the cathode plate a with addition of 0.1% by mass of a niobium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate c with addition of 0.5% by mass of a niobium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery A6.

[0025]

Further, a battery prepared by using an electrode group wherein the cathode plate b with addition of 0.2% by mass of a niobium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate c with addition of 0.5% by mass of a niobium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery A7. And further, a battery prepared by using an electrode group wherein the cathode plate c with addition of 0.5% by mass of a niobium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate c with addition of 0.5% by mass of a niobium compound is also disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery A8.

[0026]

4. Examination

(1) Measurement of High-rate Discharge Characteristic

Thereafter, the batteries A1 through A8, fabricated in the manner described above, were recharged with recharge current at 900 mA (1ItmA) with

ambient air at room temperature (about 25°C) until the voltage of each battery ($-\Delta V$), occurring after the cathode is fully charged, had dropped to 10 mV, and after a recess of one hour, 1It discharge was carried out whereby discharge with discharge current at 900 mA (1ItmA) was continued until the voltage of each battery reached 1.0V, thereby acquiring a discharge capacity X (mAh) from discharge time.

[0027]

Subsequently, the respective batteries were recharged with recharge current at 900 mA (1ItmA) with ambient air at room temperature (about 25°C) until the voltage of each battery ($-\Delta V$), occurring after the cathode is fully charged, had become 10 mV, and after a recess of one hour, 4It high-rate discharge was carried out whereby discharge with discharge current at 3600 mA (4ItmA) was continued until the voltage of each battery reached 1.0V, thereby thereby acquiring a discharge capacity Y (mAh) from discharge time. Thereafter, the ratio of Y to X $[(Y / X) \times 100\%]$ was calculated to determine the high-rate discharge characteristic at room temperature. The test results obtained are shown in Table 1 below.

[0028]

(2) Measurement of High-temperature Life Cycle

Further, the batteries A1 through A8, fabricated in the manner described above, were recharged with recharge current at 900 mA (1ItmA) with ambient temperature of 60°C for 2 hours, and subsequently discharged with discharge current at 450 mA (0.5ItmA) until the voltage of each battery reached 1.0V, which was defined as one cycle. Thereafter, recharge/discharge cycle tests were repeatedly conducted until the discharge capacity of each battery had been reduced to not more than 80% of its discharge capacity determined at the end of the first cycle at 60°C, which was defined as the high-temperature life cycle. The test results obtained are shown in Table 1 below.

[0029]

[Table 1]

battery type	nickel cathode (outer)		nickel cathode (inner)		high rate discharge at room temp. (%)	high temp. life cycle (times)
	type	add. amount (% by mass)	type	add. amount (% by mass)		
A1	a	no addition	d	no addition	82	100
A2	c	0.5	d	no addition	78	250
A3	d	no addition	a	0.1	80	290
A4	d	no addition	b	0.2	81	400
A5	d	no addition	c	0.5	80	410
A6	a	0.1	c	0.5	78	430
A7	b	0.2	c	0.5	75	440
A8	c	0.5	c	0.5	55	450

[0030]

As is evident from the results shown in Table 1 above, the battery A1 wherein the cathode plate d without addition of a niobium compound was disposed as the cathode plate 11-1 on the respective outer portions of the electrode group, and also as the cathode plate 11-2 in the respective inner portions of the electrode group, a high temperature cycle life considerably deteriorated to 100 cycles. Further, in the case of the battery A2 as well, wherein the cathode plate c with addition of 0.5% by mass of a niobium compound was disposed as the cathode plate 11-1 on the respective outer portions of the electrode group, and the cathode plate d without addition of a niobium compound was disposed as the cathode plate 11-2 in the respective inner portions of the electrode group, a high temperature cycle life deteriorated to 250 cycles.

[0031]

In contrast, in the case of the battery A5 wherein the cathode plate c with addition of 0.5% by mass of a niobium compound was disposed as the cathode plate 11-2 in the respective inner portions of the electrode group, and the cathode plate d without addition of a niobium compound was disposed as the cathode plate 11-1 on the respective outer portions of the electrode group, a high temperature cycle life was considerably enhanced to 410 cycles. This proves that use of the cathode plates c with the niobium compound added thereto results in enhancement of high temperature cycle life, however, it would be more effective if the cathode plate c with the niobium compound added thereto were to reside in the respective inner portions of the electrode group.

[0032]

If no niobium compound is added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group, the degradation rate thereof will be higher than that of the cathode plate 11-1 disposed on the respective outer portions (on the sides adjacent to the outer case 15) of the electrode group, where temperature is lower than that in the respective inner portions of the electrode group. This may be explained by the fact that the cathode plate 11-2 disposed in the respective inner portions of the electrode group reached the end of its life sooner than the cathode plate 11-1 disposed on the respective outer portions of the electrode group reached the end of its life, so that the battery as a whole came to have a shorter life.

[0033]

On the other hand, if a niobium compound is added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group, where temperature rises, degradation occurring to the respective cathode plates 11-2 due to high temperature can be inhibited. As a result, balance in degradation rate can be maintained between the cathode plates 11-2 disposed in the inner portions of the electrode group, respectively, and the cathode plates 11-1 disposed on the outer portions of the electrode group, respectively. Accordingly, it is believed that the high temperature cycle life can be enhanced by disposing the cathode plate c with the niobium compound added thereto in the same manner that the cathode plate 11-2 is disposed in the respective inner parts of the electrode group.

[0034]

Further, in the case of the battery A8 wherein the cathode plate c with addition of 0.5% by mass of the niobium compound was disposed as the cathode plate 11-1 on the respective outer sides of the electrode group, and also as the cathode plate 11-2 in the respective inner parts of the electrode groups, the high rate discharge characteristic at room temperature considerably deteriorated by 55% although the high-temperature cycle life was as large as 450 cycles. In contrast, in the case of the battery A7 wherein the cathode plate c with addition of 0.5% by mass of the niobium compound was disposed as the cathode plate 11-2 in the respective inner portions of the electrode group, and the cathode plate b with an adding amount of the niobium compound, reduced to 0.2% by mass, was disposed as the cathode plate 11-1 on the respective outer portions of the electrode group, the high temperature cycle life was as large as 440 cycles, and the high rate discharge characteristic at room temperature as well was enhanced by 75%.

[0036]

In the case of the battery A5 wherein the cathode plate c with addition of 0.5% by mass of the niobium compound was disposed as the cathode plate 11-2 in

the respective inner portions of the electrode group, and the cathode plate d without addition of the niobium compound was disposed as the cathode plate 11-1 on the respective outer portions of the electrode group, the high temperature cycle life was as large as 410 cycles, and the high rate discharge characteristic at room temperature was further enhanced by 80%.

It may thus be concluded that with respect to the cathode plate 11-1 disposed on the respective outer sides of the electrode group, increasing the amount of a niobium compound to be added will have an adverse effect on high temperature cycle life, so that the amount of niobium compound to be added to the cathode plate 11-1 disposed on the respective outer sides of the electrode group must be controlled.

[0037]

Further, with respect to the battery A3 wherein the cathode plate a with addition of 0.1% by mass of the niobium compound was disposed as the cathode plate 11-2 in the respective inner portions of the electrode group, and the cathode plate d without addition of the niobium compound was disposed as the cathode plate 11-1 on the respective outer portions of the electrode group, the high-temperature cycle life deteriorated to 290 cycles while the high-rate discharge characteristic at room temperature was as high as 80%. In contrast, in the case of the battery A4 wherein the cathode plate B2 with addition of 0.2% by mass of the niobium compound was disposed as the cathode plate 11-2 in the respective inner portions of the electrode group; and the cathode plate d without addition of the niobium compound was disposed as the cathode plate 11-1 on the respective outer portions of the electrode group, the high rate discharge characteristic at room temperature was as high as 81% and the high temperature cycle life as well was enhanced to 400 cycles.

[0037]

This proves that if the amount of niobium compound to be added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group is insufficient, it would not result in the enhancement of high temperature cycle life. Accordingly, the amount of niobium compound to be added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group should preferably be not less than 0.2% by mass. However, if the amount of niobium compound to be added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group is excessively increased, the high rate discharge characteristic at room temperature will deteriorate, and accordingly, the amount to be added should preferably correspond to the minimum required amount.

[0038]

The experimental results are summed up that, the high-temperature cycle life of the battery is enhanced by using a niobium compound added cathode plate. To maximize effectivity, however, the cathode plates with the titanium compound added thereto should be disposed in the respective inner portions of the electrode group. In such a case, if the amount of niobium compound to be added to the cathode plate 11-1 disposed in the respective outer parts of the electrode group is excessively increased, the high rate discharge characteristic at room temperature will deteriorate, and the amount of niobium compound to be added to the cathode plate 11-1 disposed on the respective outer sides of the electrode group must be controlled.

[0039]

This proves that if the amount of niobium compound to be added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group is insufficient, it would not result in the enhancement of high temperature cycle life. Accordingly, the amount of niobium compound to be added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group should preferably be not less than 0.2% by mass. However, if the amount of niobium compound to be added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group is excessively increased, the high rate discharge characteristic at room temperature will deteriorate, and accordingly, the amount to be added should preferably correspond to the minimum required amount.

[0040]

5. Studies on Compounds That May Be Added

In the foregoing examples, various cases of adding the niobium compound into the cathode plates are described, however, studies were also made on various cases of adding a titanium compound (for example, TiO_2), tungsten compound (for example, WO_2), and molybdenum compound (for example, MoO_3) to the cathode plates, respectively.

[0042]

(1) Titanium Compounds

By adding TiO_2 as a titanium compound to the cathode active material (composed of nickel hydroxide coated with a cobalt compound) prepared in the same way as previously described such that the amount of TiO_2 to be added corresponds to 0.1% by mass in relation to the mass of the cathode active material, an active material slurry was prepared, and designated as active material slurry e1. Similarly, an active material slurry similarly prepared by adding TiO_2 in an amount corresponding to 0.2% by mass was designated as active material slurry

f1, and an active material slurry similarly prepared by adding TiO_2 in an amount corresponding to 0.5% by mass was designated as active material slurry g1. In this connection, the titanium compound to be added may be made of a compound selected from the group consisting of Ti_2O_3 , TiO , $\text{Na}_2\text{Ti}_3\text{O}_7$, Li_2TiO_3 , K_2TiO_3 and so forth, besides TiO_2 .

[0042]

Thereafter, the active material slurries e1 through g1 were poured into electrode base plates made of porous nickel, respectively, as previously described, and the respective electrode base plates were dried and rolled then cut to a predetermined size, thereby preparing nickel cathode plates e through g. A nickel cathode plate prepared by using the active material slurry e1 was designated as nickel cathode plate e, a nickel cathode plate prepared by using the active material slurry f1 was designated as nickel cathode plate f, and a nickel cathode plate prepared by using the active material slurry g1 was designated as nickel cathode plate g, respectively. Subsequently, using the nickel cathode plates e through g, respectively, and the hydrogen storage alloy anode plate prepared as previously described, the respective nickel-hydrogen batteries square in shape with a nominal capacity of 900 mAh were prepared in the same way as previously described.

[0043]

A battery prepared by using an electrode group wherein the cathode plate g with addition of 0.5% by mass of a titanium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate d without addition of a titanium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery B2. Further, a battery prepared by using electrode groups wherein the cathode plate d without addition of a titanium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate e with addition of 0.1% by mass of a titanium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery B3. Furthermore, a battery prepared by using an electrode group wherein the cathode plate d without addition of a titanium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate f with addition of 0.2% by mass of a titanium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode groups was designated as battery B4.

[0045]

A battery prepared by using an electrode group wherein the cathode plate

d without addition of a titanium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate g with addition of 0.5% by mass of a titanium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode groups was designated as battery B5. Further, a battery prepared by using an electrode group wherein the cathode plate e with addition of 0.1% by mass of a titanium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate g with addition of 0.5% by mass of a titanium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode groups was designated as battery B6.

[0045]

Further, a battery prepared by using an electrode group wherein the cathode plate f with addition of 0.2% by mass of a titanium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate g with addition of 0.5% by mass of a titanium compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery B7. And further, a battery prepared by using an electrode group wherein the cathode plate g with addition of 0.5% by mass of a titanium compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate g with addition of 0.5% by mass of a titanium compound is also disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery B8.

[0046]

Thereafter, using the batteries, B2 through B8, fabricated in the manner described above, a battery with a high rate discharge characteristic at room temperature and a high temperature cycle life (capacity-maintaining ratio) was found. The test results obtained as well as the results concerning the battery J1 previously described are shown in Table 2 below.

[0047]

[Table 2]

battery type	nickel cathode (outer)		nickel cathode (inner)		high rate discharge at room temp. (%)	High temp. cycle life (times)
	type	add. amount (% by mass)	type	add. Amount (% by mass)		
A1	d	no addition	d	no addition	82	100
B2	g	0.5	d	no addition	79	230
B3	d	no addition	e	0.1	80	270
B4	d	no addition	f	0.2	80	390
B5	d	no addition	g	0.5	79	410
B6	e	0.1	g	0.5	78	410
B7	f	0.2	g	0.5	74	420
B8	g	0.5	g	0.5	57	430

[0048]

As can be derived from the above, the results shown in Table 2 above are substantially similar to the results shown in Table 1. Accordingly, it may be concluded that the high temperature cycle life can also be enhanced by using a cathode plate with a titanium compound added thereto. To maximize effectivity, however, the cathode plates with the titanium compound added thereto should be disposed in the respective inner portions of the electrode group. In such a case, with respect to the cathode plate 11-1 disposed on the respective outer portions of the electrode group, increasing the amount of the titanium compound to be added has an adverse effect on the high temperature cycle life, and accordingly should be controlled.

[0049]

Further, since no advantage is achieved by way of enhancing the high temperature cycle life if the amount of titanium compound to be added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group is insufficient, such amount to be added should preferably be not less than 0.2% by mass. However, it must be noted that if the amount of titanium compound added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group is excessively increased, the high rate discharge characteristic of the battery at room temperature will deteriorate. Accordingly, the amount of titanium compound to be added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group should preferably correspond to the minimum required amount for maintaining a satisfactory cycle life.

[0050]

(2) Tungsten Compounds

By adding WO_2 as a tungsten compound to the cathode active material (composed of nickel hydroxide coated with a cobalt compound) prepared in the same way as previously described such that the amount of WO_2 to be added corresponds to 0.1% by mass in relation to the mass of the cathode active material, an active material slurry was prepared, and designated as active material slurry h1. An active material slurry similarly prepared by adding WO_2 in an amount corresponding to 0.2% by mass was designated as active material slurry i1, and an active material slurry similarly prepared by adding WO_2 in an amount corresponding to 0.5% by mass was designated as active material slurry j1. Further, the tungsten compound to be added to the cathode active material may be made of a compound selected from the group consisting of WO_3 , Na_2WO_4 , Li_2WO_2 , K_2WO_4 and so forth, besides WO_2 .

[0051]

Thereafter, the active material slurries h1 through j1 were poured into electrode base plates made of porous nickel, as previously described, respectively, and the respective electrode base plates were dried and rolled then cut to a predetermined size, thereby preparing nickel cathode plates h through j. A nickel cathode plate prepared by using the active material slurry h1 was designated as cathode plate h, a nickel cathode plate prepared by using the active material slurry i1 was designated as cathode plate I, and a nickel cathode plate prepared by using the active material slurry j1 was designated as cathode plate j, respectively. Subsequently, using the nickel cathode plates h through j, respectively, and the hydrogen storage alloy anode plate prepared as previously described, nickel-hydrogen batteries, C2 through C8, square in shape, with a nominal capacity of 900 mAh, were prepared in the same way as previously described.

[0052]

A battery prepared by using an electrode group wherein the cathode plate j with addition of 0.5% by mass of a tungsten compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate d without addition of the tungsten compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery C2. Further, a battery prepared by using an electrode group wherein the cathode plate d without addition of a tungsten compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate h with addition of 0.1% by mass of the tungsten compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as

battery C3. Furthermore, a battery prepared by using an electrode group wherein the cathode plate d without addition of a tungsten compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate i with addition of 0.2% by mass of the tungsten compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery C4.

[0053]

Further, a battery prepared by using an electrode group wherein the cathode plate d without addition of a tungsten compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate j with addition of 0.5% by mass of the tungsten compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery C5. And further, a battery prepared by using an electrode group wherein the cathode plate h with addition of 0.1% by mass of a tungsten compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate j with addition of 0.5% by mass of the tungsten compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery C6.

[0054]

Further, a battery prepared by using an electrode group wherein the cathode plate i with addition of 0.2% by mass of a tungsten compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate j with addition of 0.5% by mass of the tungsten compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery C7. And further, a battery prepared by using an electrode group wherein the cathode plate j with addition of 0.5% by mass of a tungsten compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate j with addition of 0.5% by mass of a tungsten compound is also disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery C8.

[0055]

Thereafter, using the batteries, C2 through C8, fabricated in the manner described above, respectively, an alkaline storage battery with high rate discharge characteristic at room temperature and a high temperature cycle life (capacity-maintaining ratio) was found. The test results obtained as well as the results concerning the battery A1 previously described are shown in Table 3 below.

[0056]

[Table 3]

Battery type	nickel cathode (outer)		nickel cathode (inner)		high rate discharge at room temp. (%)	high temp. cycle life (times)
	type	add. amount (% by mass)	type	add. Amount (% by mass)		
A1	d	no addition	d	no addition	82	100
C2	j	0.5	d	no addition	80	200
C3	d	no addition	h	0.1	81	270
C4	d	no addition	i	0.2	80	390
C5	d	no addition	j	0.5	79	410
C6	h	0.1	j	0.5	78	430
C7	i	0.2	j	0.5	75	430
C8	j	0.5	j	0.5	51	430

[0057]

As can be derived from the above, the results shown in Table 3 above are substantially similar to the results shown in Tables 1 and 2. Accordingly, it may be concluded that the high temperature cycle life can also be enhanced by using a cathode plate with a tungsten compound added thereto. To maximize effectivity, however, the cathode plates with the tungsten compound added thereto should be disposed in the respective inner portions of the electrode group. In such a case, with respect to the cathode plate 11-1 disposed on the respective outer portions of the electrode group, increasing the amount of the tungsten compound to be added has an adverse effect on the high temperature cycle life, and accordingly should be controlled. As in the previously described case of the niobium compound, the amount of titanium compound to be added should be not more than 1.0% by mass.

[0058]

Further, since no advantage is achieved by way of enhancing the high temperature cycle life if the amount of tungsten compound to be added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group is insufficient, such amount to be added should preferably be not less than 0.2% by mass. However, it must be noted that if the amount of tungsten compound added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group is excessively increased, the high rate discharge characteristic of the battery at room temperature will deteriorate. Accordingly, the amount of tungsten compound to be added to the cathode plate 11-2 disposed in the respective inner parts of the electrode group should preferably correspond to the minimum required amount for maintaining a satisfactory cycle life.

[0059]

(3) Molybdenum Compounds

By adding MoO_3 as a molybdenum compound to the cathode active material (composed of nickel hydroxide coated with a cobalt compound) prepared in the same way as previously described such that the amount of MoO_3 to be added corresponds to 0.1% by mass in relation to the mass of the cathode active material, an active material slurry was prepared, and designated as an active material slurry k1. An active material slurry similarly prepared by adding MoO_3 in an amount corresponding to 0.2% by mass was designated as active material slurry l1, and an active material slurry similarly prepared by adding MoO_3 in an amount corresponding to 0.5% by mass was designated as active material slurry m1. In this connection, the molybdenum compound to be added may be made of a molybdenum compound selected from the group consisting of $\text{MoO}_3 \cdot \text{H}_2\text{O}$, $\text{MoO}_3 \cdot 2\text{H}_2\text{O}$, $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, $\text{Li}_6\text{Mo}_7\text{O}_{24} \cdot 12\text{H}_2\text{O}$, K_2MoO_4 and so forth, besides MoO_3 .

[0060]

Thereafter, the active material slurries k1 through m1 were poured into electrode base plates made of porous nickel as previously described, respectively, and the respective electrode base plates were dried and rolled then cut to a predetermined size, thereby preparing nickel cathode plates k through m. A nickel cathode prepared by using the active material slurry k1 was designated as cathode plate k, a nickel cathode plate prepared by using the active material slurry l1 was designated as cathode plate l, and a nickel cathode plate prepared by using active material slurry m1 was designated as cathode plate m, respectively. Subsequently, using the nickel cathode plates l through m, respectively, and the hydrogen storage alloy anode plate prepared as previously described, respective nickel-hydrogen batteries, D2 through D8, square in shape, with a nominal capacity of 900 mAh, were prepared in the same way as previously described.

[0061]

A battery prepared by using an electrode group wherein the cathode plate m with addition of 0.5% by mass of a molybdenum compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group, and the cathode plate d without addition of the molybdenum compound is disposed as a cathode plate 11-2 in respective inner portions of the electrode group was designated as battery D2. Further, a battery prepared by using an electrode group wherein the cathode plate d without addition of a molybdenum compound is disposed as a cathode plate 11-1 on respective outer portions of the electrode group and the cathode plate k with addition of 0.1% by mass of the molybdenum compound is disposed as a cathode plate 11-2 in respective inner portions of the

electrode group was designated as D3. And further, a battery prepared by using an electrode group wherein the cathode plate d without addition of a molybdenum compound is disposed as a cathode plate 11- 1 on respective outer portions of the electrode group and the cathode plate l with addition of 0.2% by mass of the molybdenum compound is disposed as a cathode plate 11- 2 in respective inner portions of the electrode group was designated as battery D4.

[0062]

A battery prepared by using an electrode group wherein the cathode plate d without addition of a molybdenum compound is disposed as a cathode plate 11- 1 on respective outer portions of the electrode group and the cathode plate m with addition of 0.5% by mass of the molybdenum compound is disposed as a cathode plate 11- 2 in respective inner portions of the electrode group was designated as battery D5. Further, a battery prepared by using an electrode group wherein the cathode plate k with addition of 0.1% by mass of a molybdenum compound is disposed as a cathode plate 11- 1 on respective outer portions of the electrode group and the cathode plate m with addition of 0.5% by mass of the molybdenum compound is disposed as a cathode plate 11- 2 in respective inner portions of the electrode group was designated as battery D6.

[0063]

Further, a battery prepared by using an electrode group wherein the cathode plate l with addition of 0.2% by mass of a molybdenum compound is disposed as a cathode plate 11- 1 on respective outer portions of the electrode group and the cathode plate m with addition of 0.5% by mass of the molybdenum compound is disposed as a cathode plate 11- 2 in respective inner portions of the electrode group was designated as battery D7. And further, a battery prepared by using an electrode group wherein the cathode plate m with addition of 0.5% by mass of a molybdenum compound is disposed as a cathode plate 11- 1 on respective outer portions of the electrode group and the cathode plate m with addition of 0.5% by mass of a molybdenum compound is also disposed as a cathode plate 11- 2 in respective inner portions of the electrode group.

[0064]

Thereafter, using the batteries, D2 through D8, fabricated in the manner described above, a battery with a high rate discharge characteristic at room temperature and a high temperature cycle life (capacity-maintaining ratio) was found, The test results obtained as well as the results concerning the battery A1 previously described are also shown in Table 4 below.

[0065]

[Table 4]

battery type	nickel cathode (outer)		nickel cathode (inner)		high rate discharge at room temp. (%)	high temp. cycle life (times)
	type	add. amount (% by mass)	type	add. Amount (% by mass)		
A1	d	no addition	d	no addition	82	100
D2	m	0.5	d	no addition	78	190
D3	d	no addition	k	0.1	81	280
D4	d	no addition	l	0.2	79	400
D5	d	no addition	m	0.5	79	420
D6	k	0.1	m	0.5	78	430
D7	l	0.2	m	0.5	74	440
D8	m	0.5	m	0.5	49	440

[0066]

As can be derived from the above, the results shown in Table 4 above are substantially similar to the results shown in Tables 1, 2 and 3. Accordingly, it may be concluded that the high temperature cycle life can also be enhanced by using a cathode plate with a molybdenum compound added thereto. To maximize effectivity, however, the cathode plates with the molybdenum compound added thereto should be disposed in the respective inner portions of the electrode group. In such a case, with respect to the cathode plate 11-1 disposed on the respective outer portions of the electrode group, increasing the amount of the molybdenum compound to be added has an adverse effect on the high temperature cycle life, and accordingly should be controlled.

[0067]

Further, since no advantage is achieved by way of enhancing the high temperature cycle life if the amount of molybdenum compound to be added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group is insufficient, such amount to be added should preferably be not less than 0.2% by mass. However, it must be noted that if the amount of molybdenum compound added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group is excessively increased, the high rate discharge characteristic of the battery at room temperature will deteriorate. Accordingly, the amount of molybdenum compound to be added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group should preferably correspond to the minimum required amount for maintaining a satisfactory cycle life.

[0068]

[Advantageous Effect of the Invention]

As described hereinbefore, under the invention, at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound is introduced into the nickel cathodes provided with the cathode active material composed mainly of nickel hydroxide which surface has a coating layer of cobalt compound. Accordingly, the rate at which the cobalt compound coating the surface of the active material layer composed mainly of the nickel hydroxide is dissolved and precipitated in the alkaline electrolytic solution can decrease.

[0069]

And therefore, improving of the electrically conductive network in the nickel cathode is enabled. In such a case, since the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound to be added is modified such that the amount to be added increases as the cathode is further located in the respective inner parts of the electrode group, the life cycle of the cathode disposed in the respective inner parts of the electrode group is greatly enhanced, regardless of an increase in temperature of the battery. As a result, this will lead to enhancement of the life cycle of the battery as a whole.

[0070]

In the foregoing examples embodying the invention cases where the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound to be added to the cathode plate 11-1 disposed on the respective outer portions of the electrode group is decreased while increasing the amount of any of the aforementioned compounds to be added to the cathode plate 11-2 disposed in the respective inner portions of the electrode group have been described. However, where an electrode group comprising a large number of cathode plates disposed therein is to be used, the electrode group may be configured such that the cathode plates are disposed in such a way as to allow the addition of those compounds to increase in sequence from the outer portion of the electrode group toward the inner portion thereof.

[0071]

Further, the foregoing examples have illustrated cases of fabricating an alkaline storage battery using the electrode group formed by disposing the cathode plates 11 in flat plate shape and the anode plates 12 in flat plate shape so as to oppose each other with the separator 13 interposed therebetween, and

laminating the cathode plates 11 in flat plate shape to the anode plates 12 in flat plate shape, respectively. However, the invention is not limited to those cases, and can in fact be applied to a battery cylindrical in shape, fabricated by using a spiral electrode group formed by disposing a cathode plate in webbing-like shape and an anode plate in webbing-like shape in such manner as to oppose each other with a separator interposed therebetween, and winding about both plates in spiral form before inserting the spiral electrode group into an outer case cylindrical in shape.

[0072]

In this case, fabrication is to be particularly implemented such that the cathode plates each having different amounts of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound, and molybdenum compound shall be bonded together, such that one cathode plate in webbing-like shape is formed, and an electrode group subsequently formed by winding about in spiral form the cathode plate in webbing-like shape together with a hydrogen storage alloy anode plate prepared in webbing-like shape, with the separator interposed therebetween, is inserted into the outer case cylindrical in shape.

[Brief Description of the Figures]

[Fig. 1] A schematic section view of an alkaline storage battery according to the invention

[Explanation of Symbol]

10: Nickel-hydrogen Storage Battery, 11: Nickel Cathode Plates, 11-1: Nickel Cathode Plates Disposed on the Outer Sides of the Electrode Group, 11-2: Nickel Cathode Plates Disposed on the Inner Sides of the Electrode Group, 13: Separator, 14: Cathode Current Collector, 15: Outer Case, 16: Sealing Body, 16a: Lid, 16b: Insulator Plate, 16c: Cathode Terminal Member, 16d: Gasket, 16e: Cathode Cap, 16f: Valve.

[Name of the Document] Abstract

[The Problem to be Solved]

The invention is intended to provide an alkaline storage battery with an excellent cycle life at high temperature, capable of inhibiting degradation of cathodes disposed in the inner portion of the electrode group so as to maintain a balance between the degradation rate of the cathodes disposed in the inner portion of the electrode group and the degradation rate of cathodes disposed on the outer portion of the electrode group even if there occurs a difference in temperature between the inner part and the outer side of the electrode group.

[The Means of Solving the Problem]

The cathodes of the alkaline storage battery of the invention to provide, includes a cathode active material composed mainly of nickel hydroxide, having a coating layer of a cobalt compound, and is added with at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound and molybdenum compound while the amount of at least one species of a compound selected from the group consisting of niobium compound, titanium compound, tungsten compound and molybdenum compound to be added to each of the nickel cathodes disposed in the inner portion of the electrode group is greater than that for each of the nickel cathodes disposed on the outer portion of the electrode group.

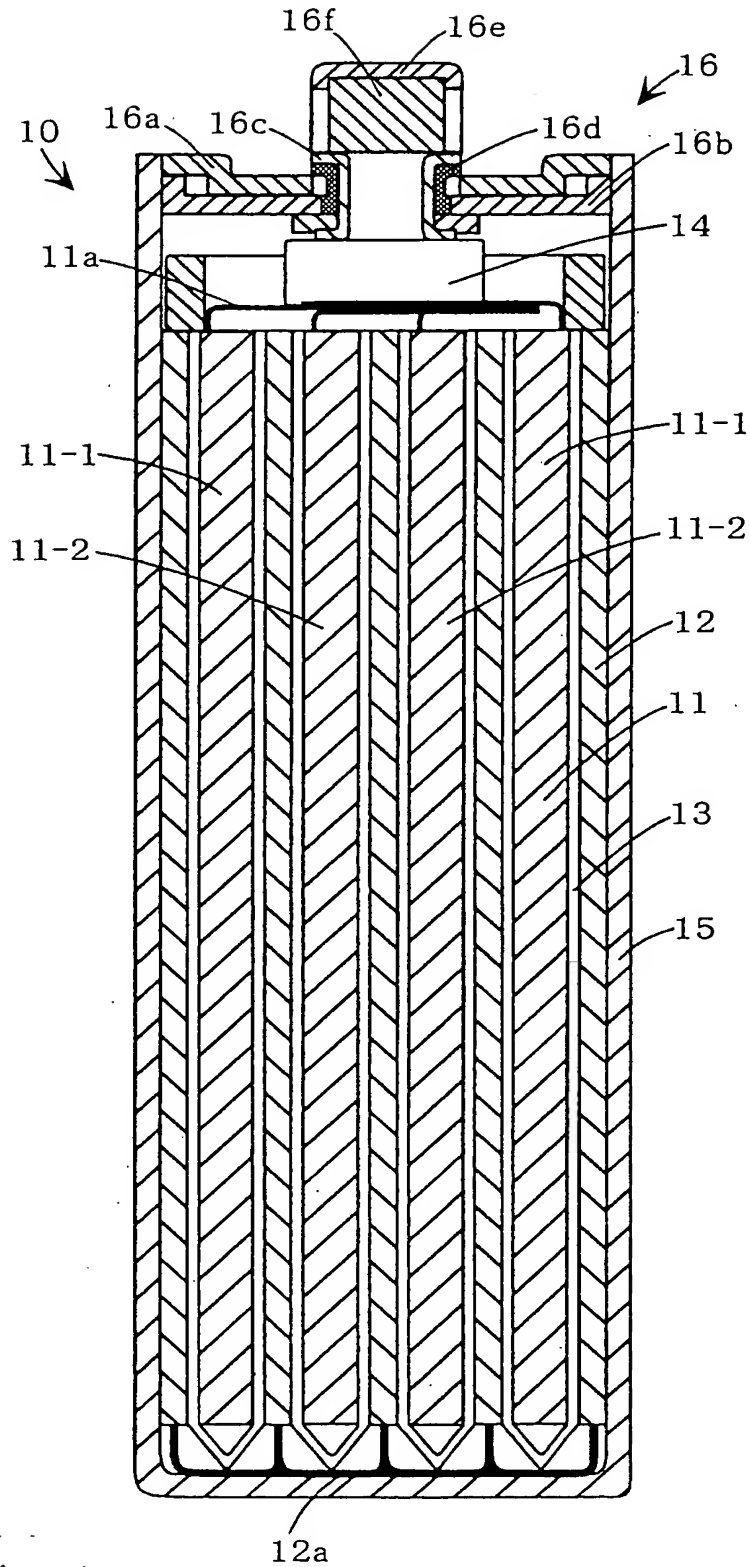


Fig. 1